EUV Materials Solution

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Contents

- What is Difference between EUV and ArF?
- EUV Material Development
  - Chemically amplified resist(CAR)
  - Sensitizer UL
  - Metal resist
- EUV Material Production
- Next Generation

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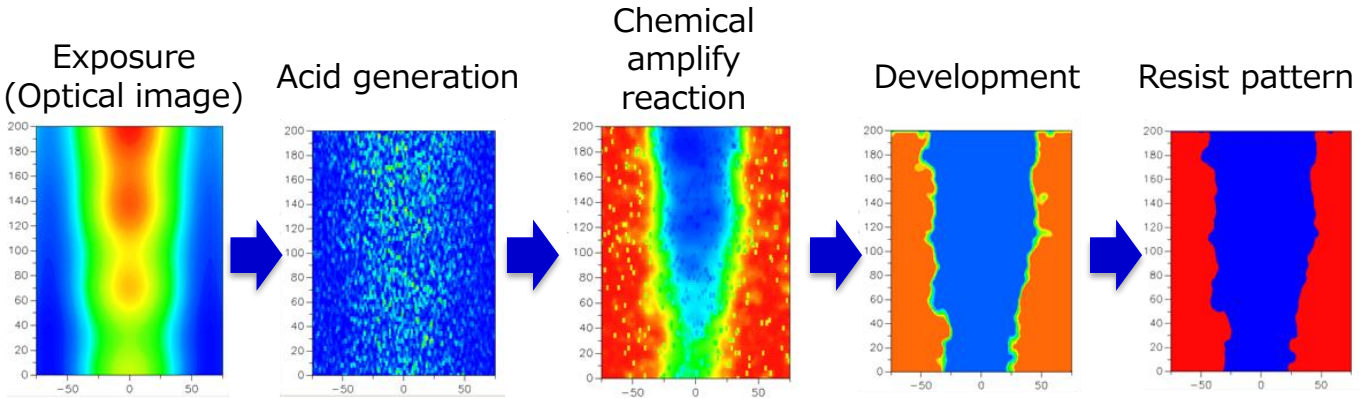
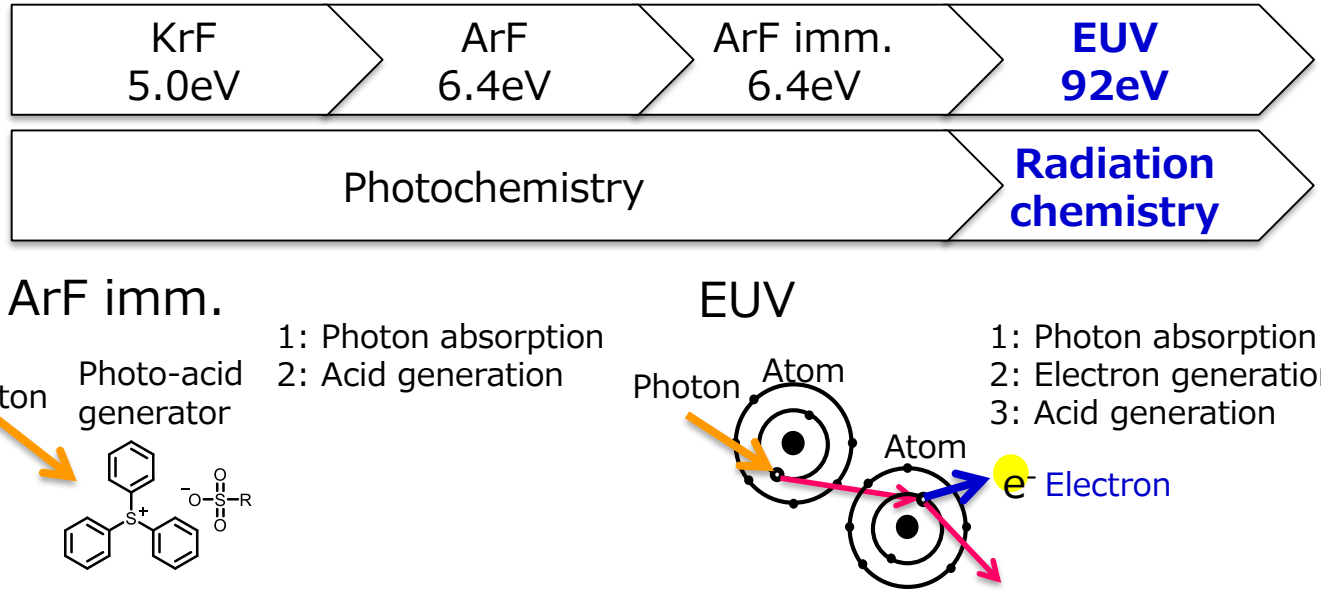
What is Difference between EUV and ArF Technology from Material Point of View?

Photo-resist patterning process



What is Difference between EUV and ArF Technology from Material Point of View?



How to Improve Resist Performance from View Point of Chemistry?

Process	• Exposure • Acid generation	• Chemical amplify reaction	• Development
Key chemical	• Absorption • Electron generation • Acid generation	• Acid diffusion control • Active energy of protecting group • Uniformity of resist component	• Dissolution rate • Dissolution contrast

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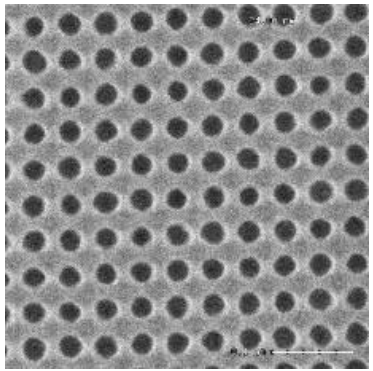
Resist Development for CH
- Pitch 44nm -

Exposed on NXE3300B

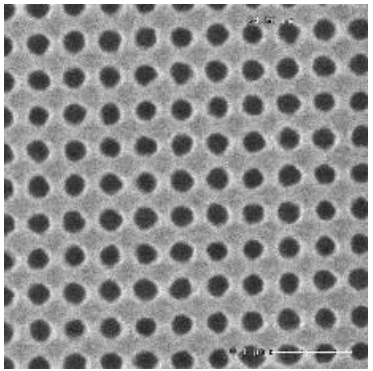
Current PAG/Polymer



Sensitivity: 36.8mJ/cm^2
LCDU: 3.46nm

26% dose
Reduction

New short ADL PAG with
New high Tg polymer



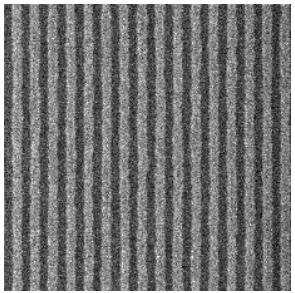
Sensitivity: 27.2mJ/cm^2
LCDU: 3.48nm

Development of new PAG/Resin enables breakthrough performance

Resist Development for LS
- Pitch 28 nm-

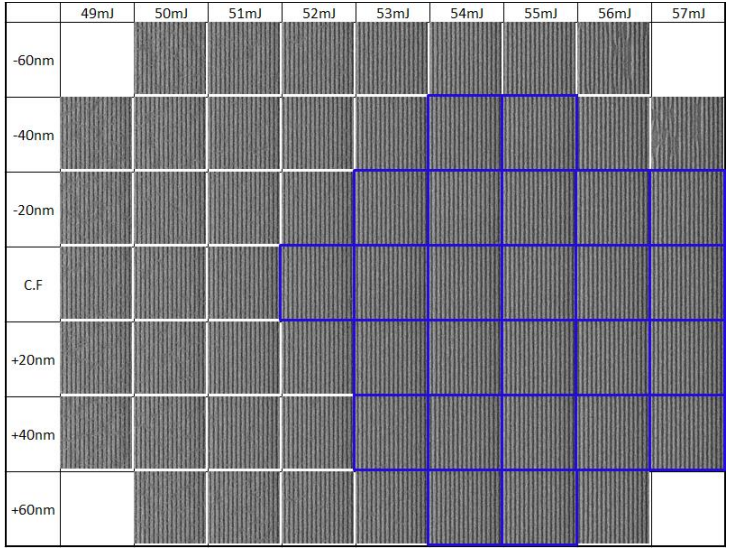
Exposed on NXE3300B

Best dose / best focus



Sensitivity: 55mJ/cm^2
LWR: 3.8nm

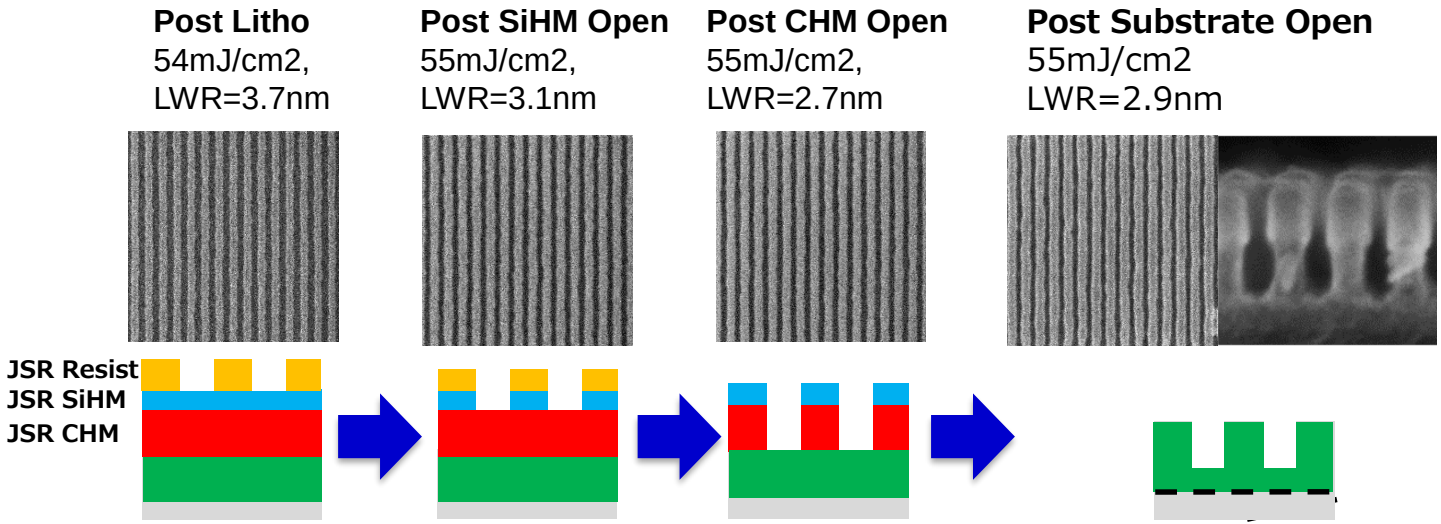
Process window



Pitch 28nm can be resolved with reasonable LWR and process window.

Etch Transfer with JSR Tri-layer Stack

-Challenging for 30nm Pitch etch transfer to dielectric film-



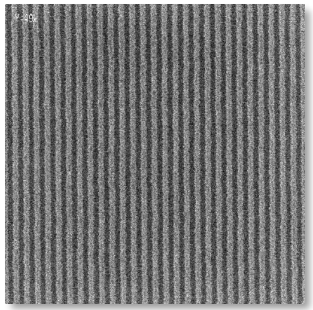
30 nm Pitch Etch transfer have been succeed with JSR tri-layer stack

Proc. SPIE 10143, Extreme Ultraviolet (EUV) Lithography VIII
https://doi.org/10.1117/12.2258164

Sensitizer Under Layer for LS
- 32 nm Pitch -

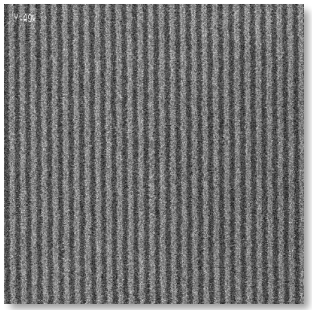
Resist / Organic UL

Sens. 28.5mJ/cm2
LWR 5.7nm



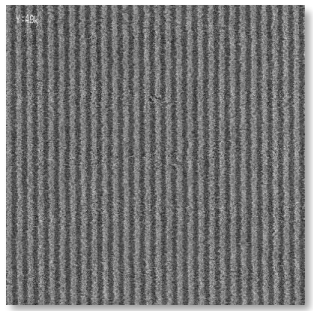
Resist / Sensitizer UL

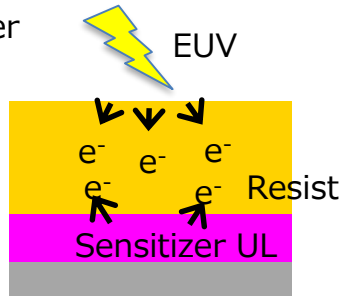
Sens. 15.5mJ/cm2
LWR 7.1nm



Resist / Sensitizer UL
(High bake temp. applied for sensitizer UL)

Sens. <9mJ/cm2
LWR >8nm





Resist sensitivity is improved by applying “Sensitizer Under layer”
The possibility of 32 nm Pitch @ under 10mJ was observed.

Proc. SPIE 10143, Extreme Ultraviolet (EUV) Lithography VIII
https://doi.org/10.1117/12.2258164

Sensitizer Under Layer for CH
- 44 nm Pitch -

Resist
on Organic UL

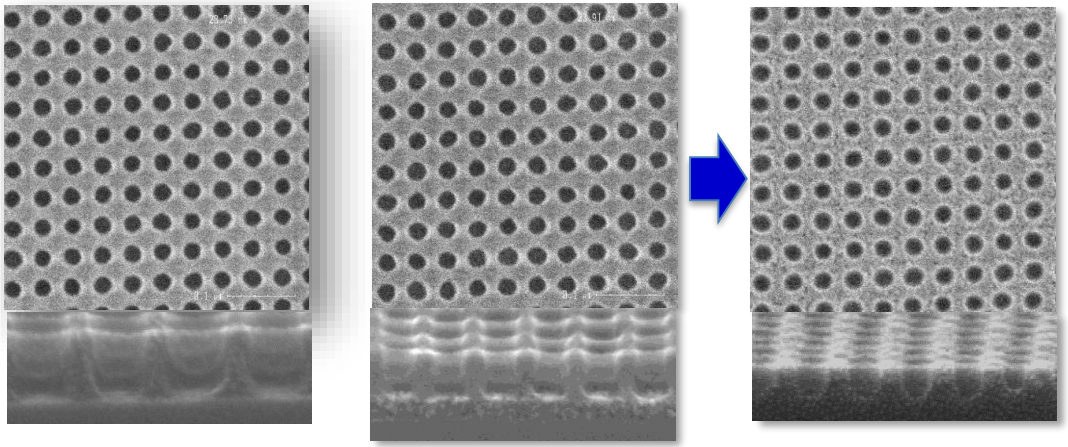
Sens. 39.0mJ/cm2
LCDU 3.8nm

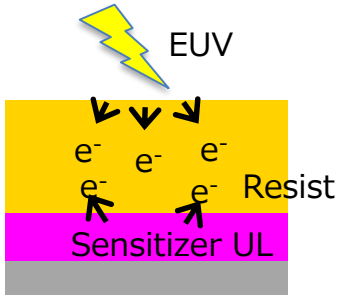
Resist
on Sensitizer UL

Sens. 30.8mJ/cm2
LCDU 3.9nm

Post Sensitizer UL open
and resist strip

Sens. 30.8mJ/cm2
LCDU 4.0nm





Sensitization was confirmed on CH and etch transfer have been demonstrated.

Proc. SPIE 10143, Extreme Ultraviolet (EUV) Lithography VIII
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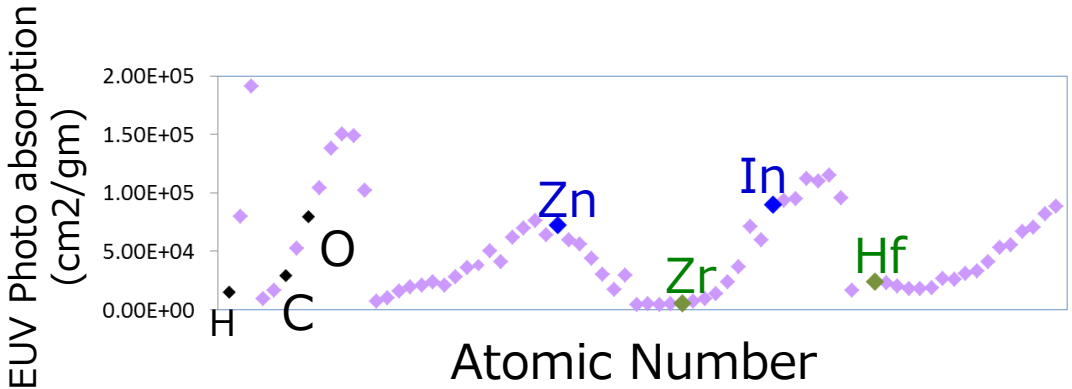
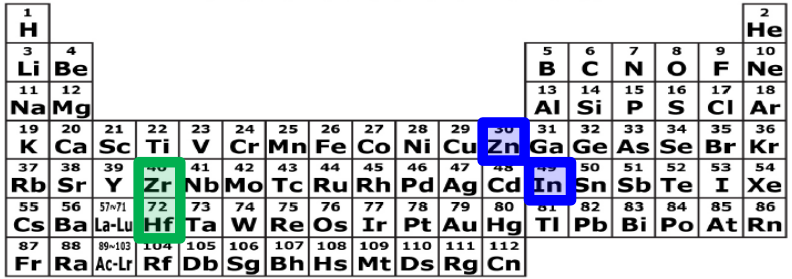
Motivation of Metal Nano Particle Resist





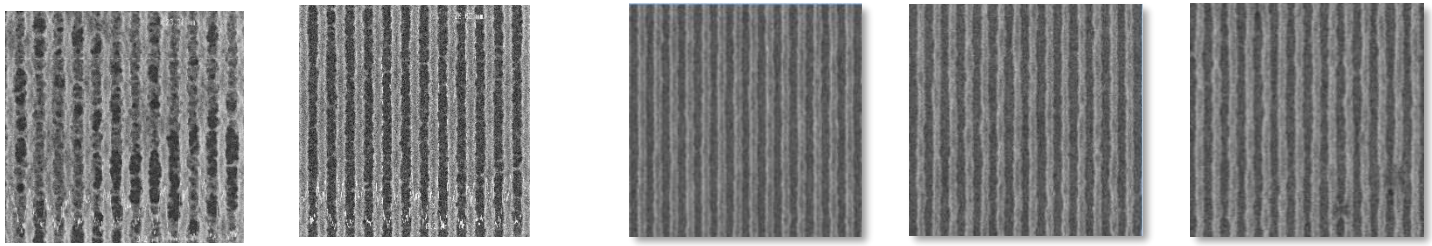
Potential Benefit of Metal resist

- High sensitivity
- High etching selectivity

Metal Nano Particle Resist Development

Exposed on NXE3300B

2015	2016	2017		
54 nm Pitch	54 nm Pitch	38 nm Pitch	36 nm Pitch	34 nm Pitch
		Sens. 56.0mJ/cm2 LWR 4.6nm	52.5mJ/cm2 7.2nm	56.0mJ/cm2 7.4nm



Resolution improvement was achieved by new Metal nano particle resist

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EUV Ready for the INDUSTRY

- EUV Resist Manufacturing & Qualification Center-

JSR partnered with imec enabling manufacturing and quality control of EUV lithography materials for the semiconductor industry.

JSR Micro JSR MATERIALS INNOVATION

EUV RMQC EUV RESIST MANUFACTURING & QUALIFICATION CENTER

imec

Manufacturing Technologies
(Production and QC analytical)

- Dedicated Manufacturing Lines and Analytical Testing Capability for EUV resists

Application Equipment (QC, functional testing.)

- ASML NXE:3300 full-field EUV scanner
- TEL Lithius Pro-Z EUV track and more…

Facility located in the existing JSR Micro NV plant.

Concept of EUV RMQC
- Foundry for EUV Photoresists -

Proximity is one of the advantages of EUV RMQC

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What is Next Generation?

$$\text{Resolution} = k_1 \frac{\lambda}{n \sin\Theta}$$

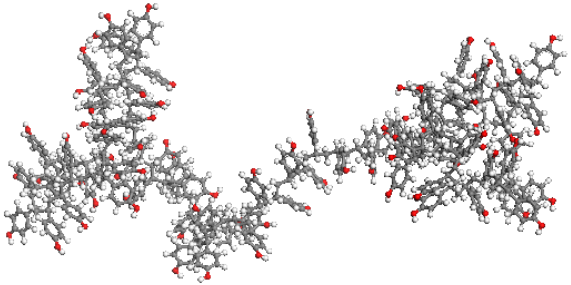
$$= k_1 \frac{\lambda}{NA}$$

$k_1 = 0.3$

Technology	Wavelength /nm	Resolution /nm	NA
g line	436	145	0.9
I line	365	122	0.9
KrF	248	83	0.9
ArF	193	64	0.9
ArF immersion	193	45	1.3
EUV (NA 0.33)	13.5	12	0.33
EUV (NA 0.5)	13.5	8	0.5
6.7 nm wavelength	6.7	4	0.5

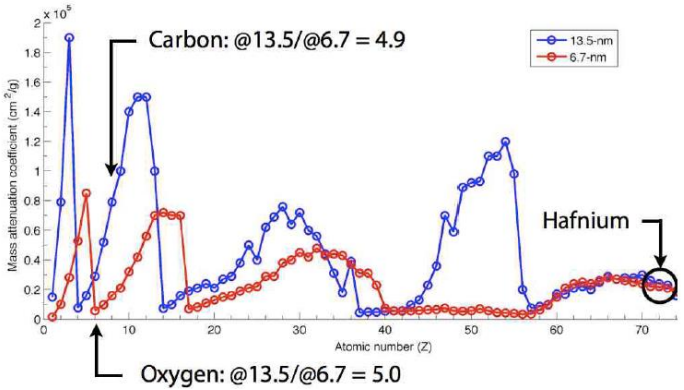
Sub-10 nm Resolution

Need to consider polymer size



Mw 8000
Polymer size : 5-7nm

Need to consider resist absorption for 6.7nm wavelength



Chris A et. al , EUVL Symposium 2011

For sub 10nm resolution, new material development is required.

Summary

- Material solutions for EUV lithography
  - Chemically amplified resist(CAR)
  - Sensitizer under layer
  - Nano particle resist
- EUV material production
  - EUV RMQC
- Material development for sub 10 nm